ANALYSIS AND DOCUMENTATION OF THE "MITHOLZ" UNDERGROUND AMMUNITION STORAGE ACCIDENTAL EXPLOSION IN SWITZERLAND

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ANALYSIS AND DOCUMENTATION OF THE "MITHOLZ" UNDERGROUND AMMUNITION STORAGE ACCIDENTAL EXPLOSION IN SWITZERLAND

BY:

HANSJÖRG RYTZ and KHOSROW BAKHTAR

ABSTRACT

A catastrophic accident took place, a year and half after the end of the Second World War (December 19 - 20, 1947), in one of the most modem underground ammunition storage magazines in Switzerland. The accident resulted in three major explosions in which nine persons from the nearby village perished. Initial estimates indicated that almost 7000 tons of ammunition was stored at the site. Almost 3000 tons was detonated, deflagrated, or burned causing structural damage. The remaining ammunition was thrown out and spread around the storage facility along with induced secondary fragments. The products of explosion, airblast, debris and fragments, caused the destruction of several houses and the local railway station in the village of "Mitholz." The Swiss authorities conducted the necessary investigation to document the mishap following the accident in late December 1947. In 1993, a new investigative and analytical approach was developed under the United States Air Force SBIR Phases I and II. This approach, "Bakhtar Explosives Safety Criteria," was tested and successfully verified at several sites in the United States and Europe. To further document the event at Mitholz and help to prevent future accidents, it was decided to perform a more elaborate investigation using the site specific information on the induced fragment ranges, and the geologic and engineered systems. This paper provides a systematic approach proposed for such investigations. It was anticipated that prior to the DDESB Seminar in August 1996, an opportunity would arise to perform site characterization at the Mitholz facility. However this did not happen and the plans are to perform such studies in the upcoming year. The site specific information obtained from the accident site will be used to demonstrate the method of analysis. The overall approach is presented in this paper.

1. INTRODUCTION

An overview is presented describing the most important aspects of the Mitholz underground ammunition storage accidental explosion in Switzerland. The documentation of this catastrophic accident, which took place two and a half years after the end of World War II, is based on the testimony from experts and other investigators. Attempts are also made to outline a unique approach recently developed through the US Air Force SBIR program for investigation of accidents in underground munitions storage facilities.

2. BACKGROUND

Blausee-Mitholz is located in the Kander Valley of the Swiss Bernese Oberland along the railroad which connects the capital Bern to the western parts of Switzerland and northern Italy. It is about 500 m south of the railway station.

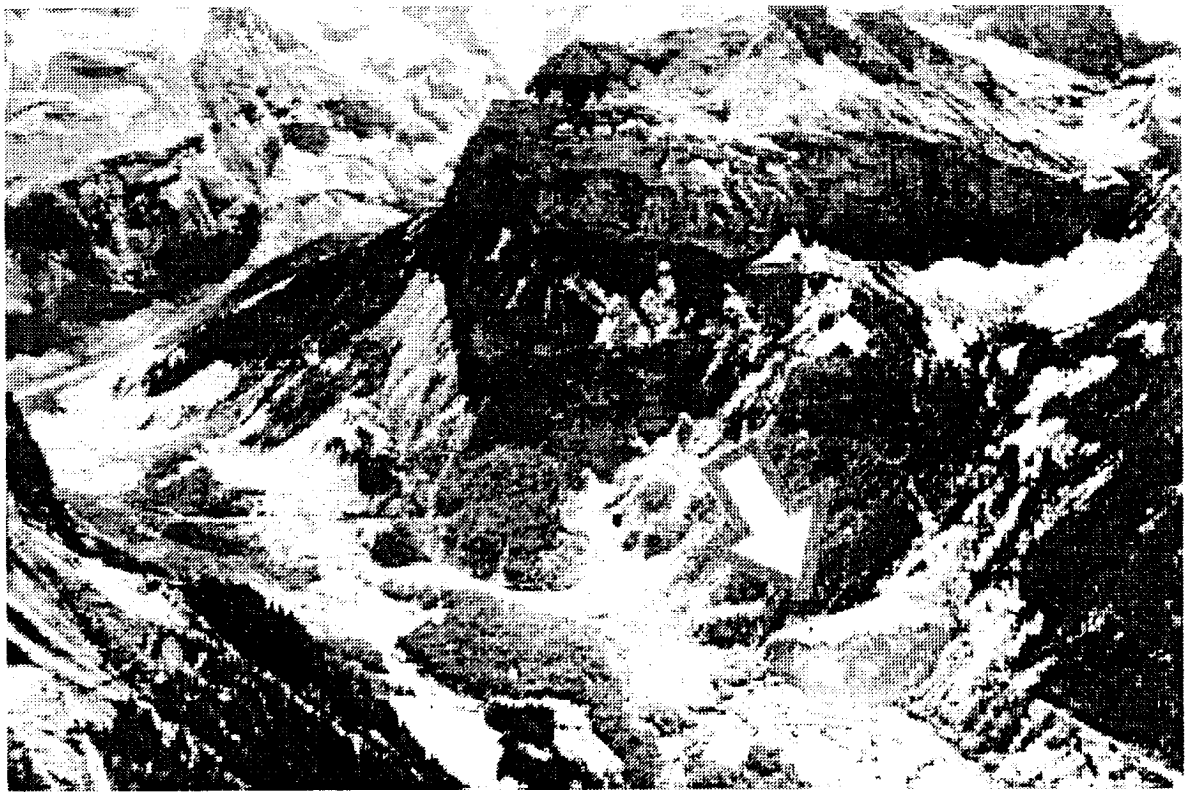


Figure 1. Site Location.

Between 1941 and 1945 the ammunition storage magazine was constructed perpendicular to a large cubical-shaped rock, 100 m high and 200 m wide striking North-South. Magazine had six typical storage chambers about 150 m long 10 m wide and separated by 16 m of rock. They were 6 to 7 m high – all ending into a railway tunnel 8 m wide

to allow for truck or train ingress (Figures 2 and 3).

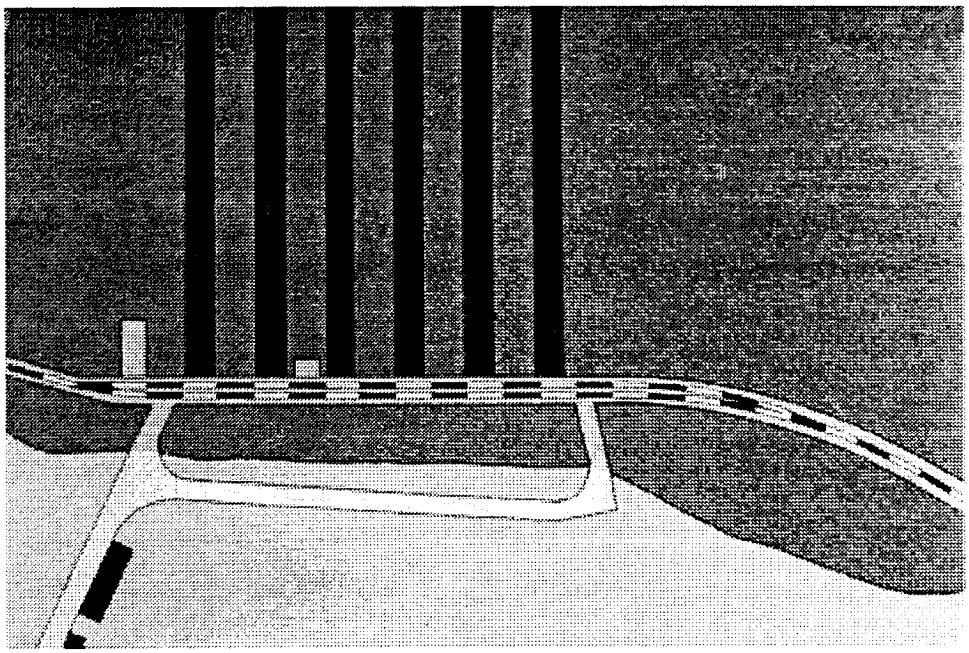


Figure 2. Layout of Storage Chambers.

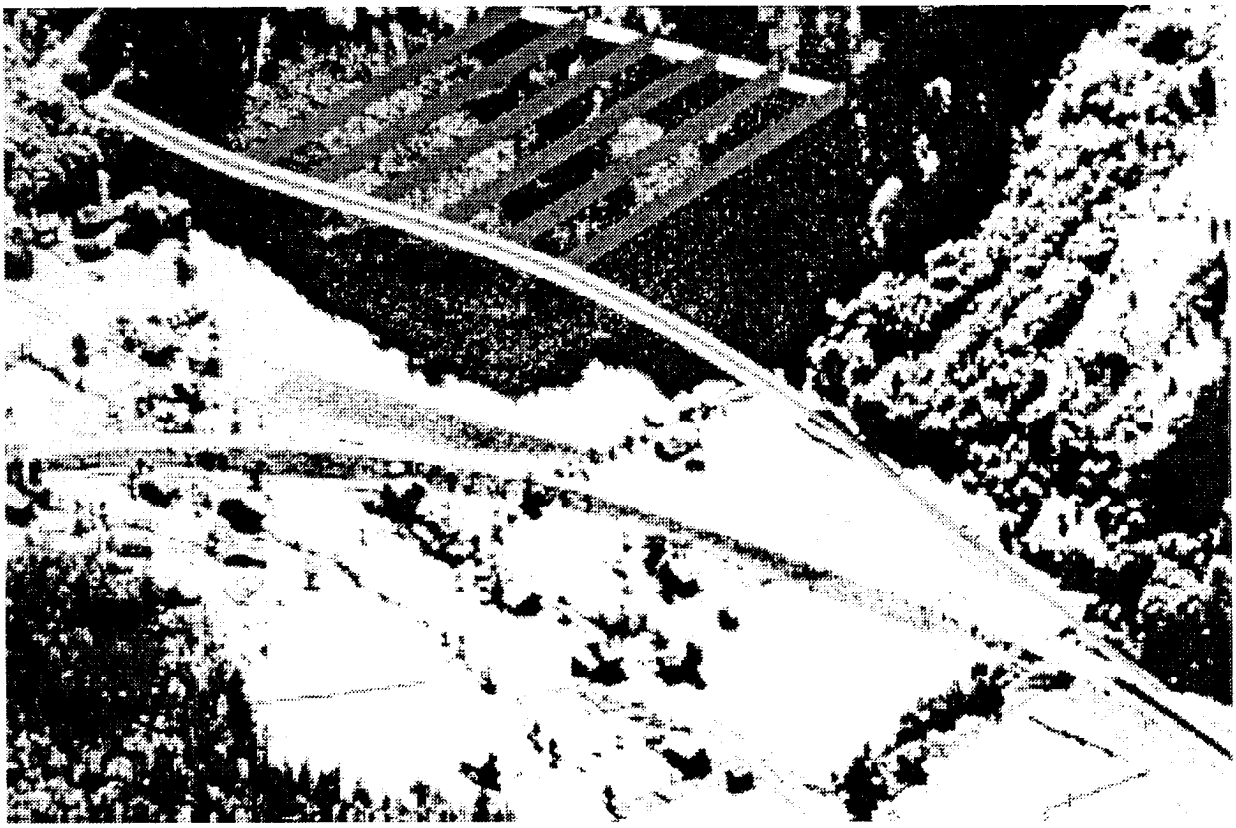


Figure 3. Superposition of Undetonated Magazine on Existing Topography.

The overburden over the chambers comprised of different limestone rock interbedded with moraine layer ranges in thickness from 100 m to about 20 m over the railway tunnel.

3. CHRONOLOGICAL CIRCUMSTANCES

On the night of December 19th 1947 around eleven o 'clock, several persons in the Kander Valley observed flashes and flames coming out of the railway tunnel. Five minutes later the population in the village of Mitholz (about 200) were awakened by loud noises resembling those of avalanches.

The first massive explosion occurred at 11:30 pm with flames escaping from all portals and ventilation openings. Blast flames reaching 30 m high set fire to several trees above the 100 meter high rock wall. At 11:35 a second big explosion occurred and was detected by the seismographs 115 km away in the Swiss Earthquake Institute. Several houses and the railway station were destroyed during this explosion as a result of falling rock and thrown ammunition.

Ten minutes past midnight the third and most powerful explosion threw out an enormous amount of ammunition, burning explosives and rock debris of various sizes - together with blast flames up to 150 m high. This followed by the collapse of the northern edge of rock wall. Figures 4 to 10 provide details of damage caused by the blast in the area.

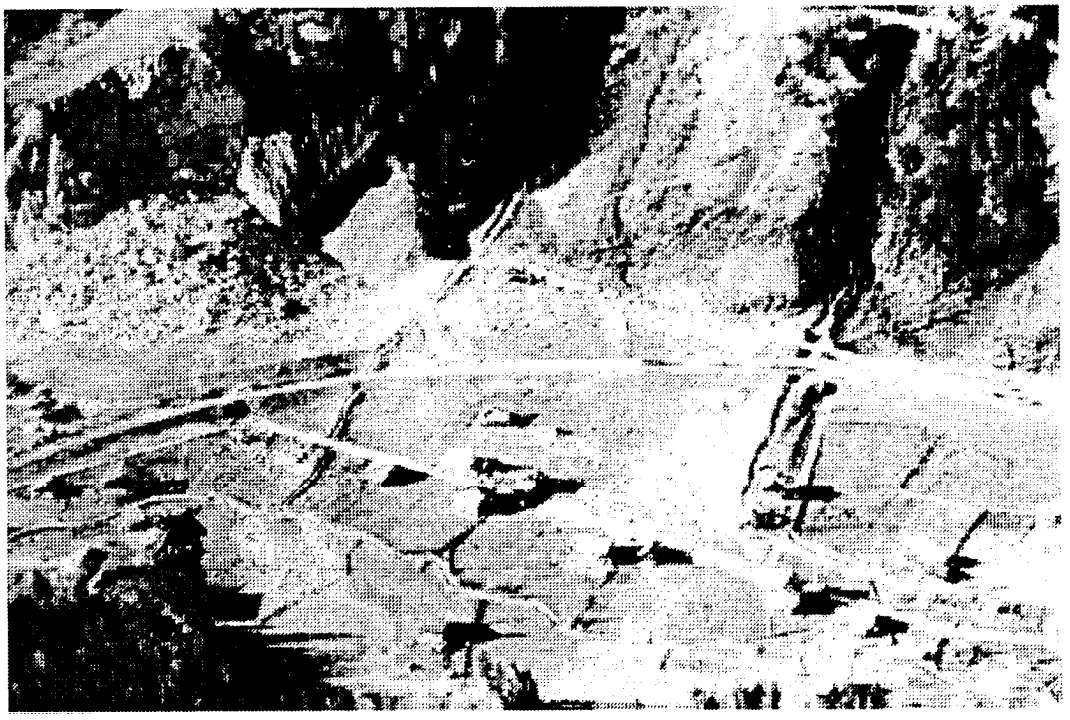


Figure 4. Photograph Showing Magazine Site Post-Blast.

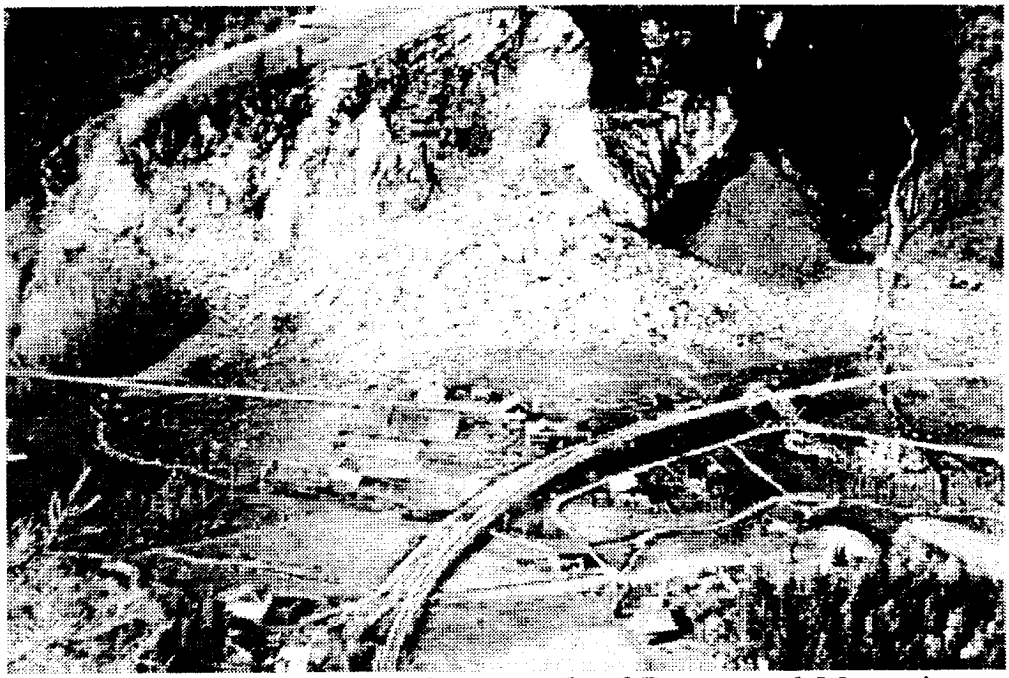


Figure 5. A Close-Up Photograph of Detonated Magazine.

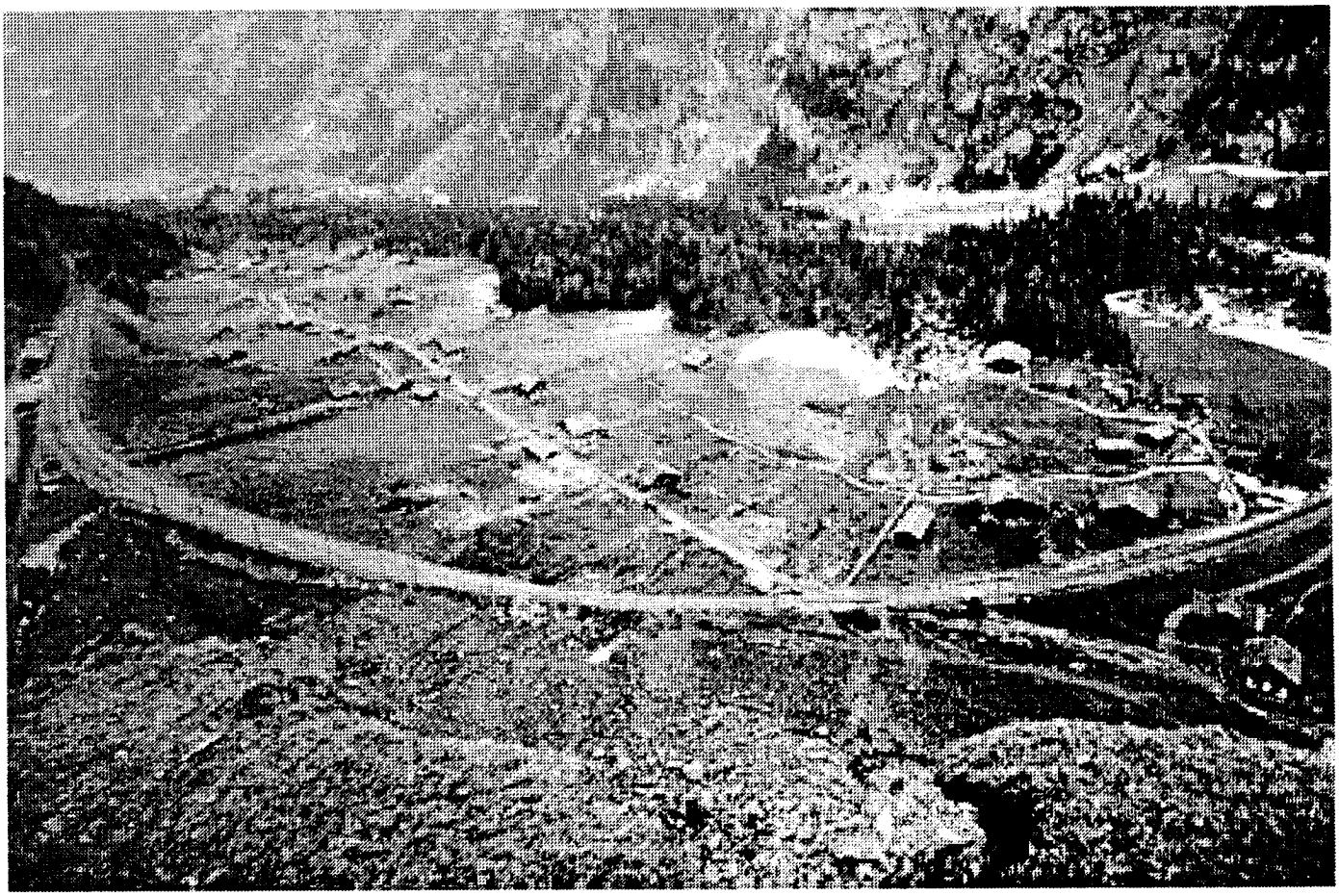


Figure 6. Overall View of Accident Site.

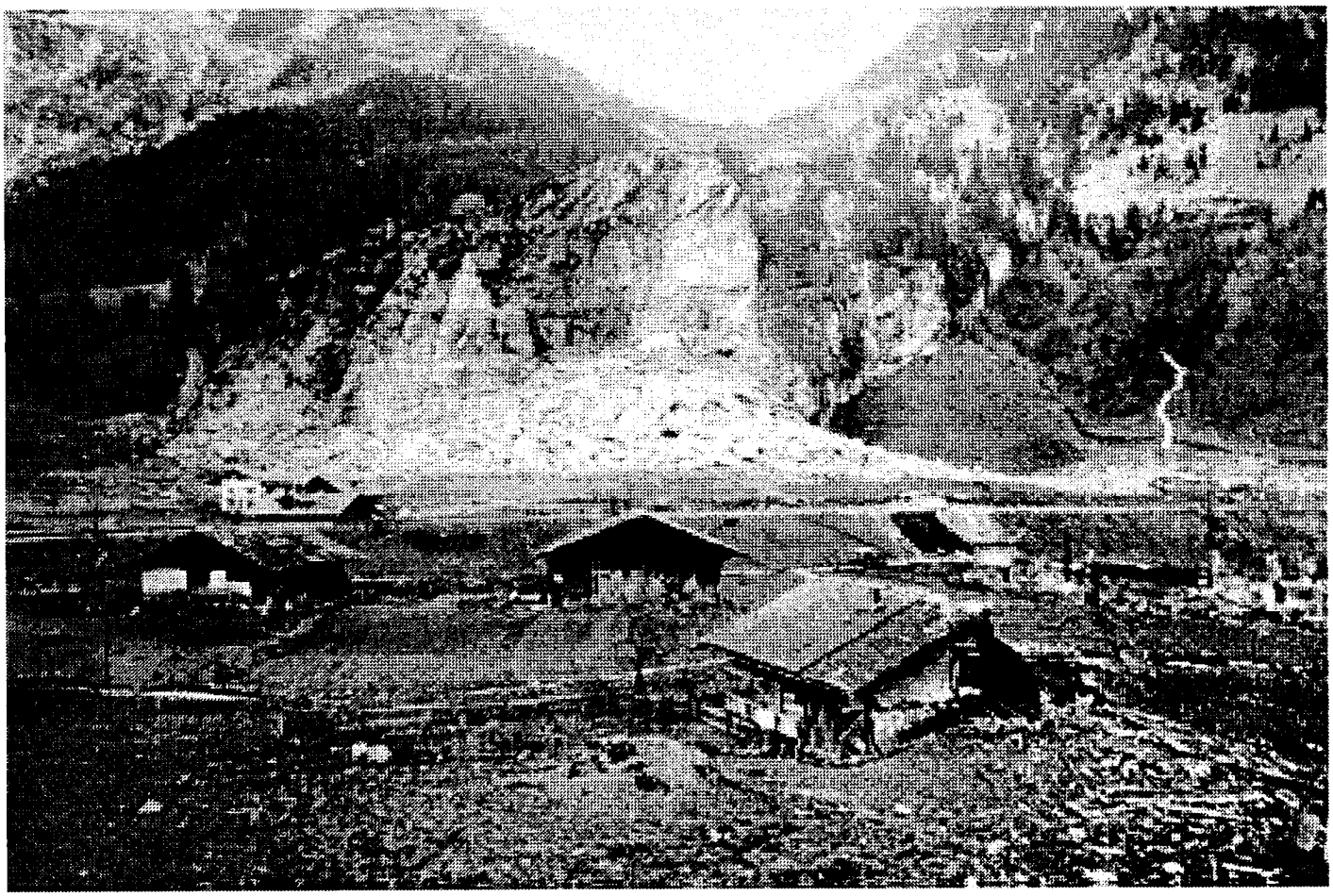


Figure 7. Showing Location of Buildings at the Accident Site.

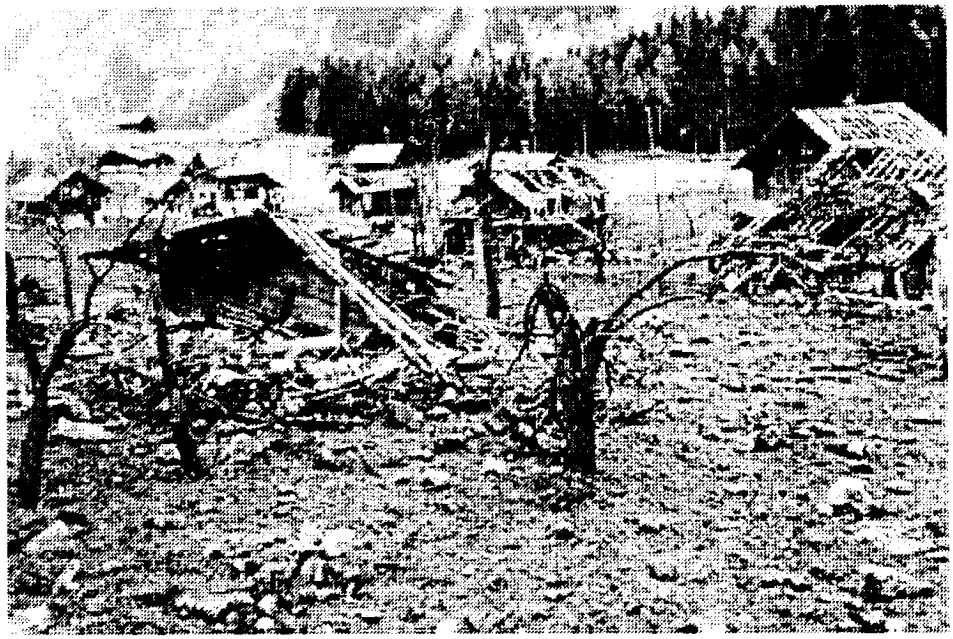


Figure 8. Observed Damage to Inhabited Buildings.

Figure 9. Photograph Showing Fragment Density Post-Blast.

Figure 10. Photograph Showing Blast-Induced Damage to the Railway Station.

The registered magnitude of the third explosion was 3.5 times the second and I5 times the first. On December 20, 1947 at about 2 a.m. a series of explosions with blast flames in the southern part of the magazine was observed. Explosions continued during the day with two major blasts taking place at nine and eleven thirty p.m.

On the night of December 21st, burning without detonation was observed. Several minor explosions took place during the period until December 28th. Rock fall and debris throw occur until the end of the year.

4. EFFECTS

It appears that the characteristics of the geologic system controlled the fragmentation and thrown distances of the ejecta at the accident site. Parallel to the railway tunnel, at the intersection of the tunnel and chambers, the presence of a major joint system with wide apertures created a weak zone against which rock breakage occurred.

The collapse of the northern edge of the rock wall (approximate total volume of 240,000 m^3) displaced the soil in a way that a part of the road was lifted up (Figure 11).

Figure 11. Structural Damage Caused to the Near-By Road.

About 15,000 m³ of rock fell in the middle and southern part of the wall.

All other damages could be clearly separated into four main damage zones (Figure 12) corresponding to the direction of the blasts away from the railway tunnel and the two portals. The fourth (smallest) zone was built when the back part of the tunnel near rock wall was destroyed.

The tremendous damage observed at the village of Mitholz was caused by the blast, explosion induced gases, and by the debris thrown out of the three portals.

The North Damage Zone was was 660 m long, however, debris were found at a range of 1300 — I800 m. This is similar to the gas tube or shock tube effects.

The Northwest Damage Zone was only 350 m long because a hill acted as a barricade to contain the blast. The damage in this zone appeared to be more extensive and destroyed three houses.

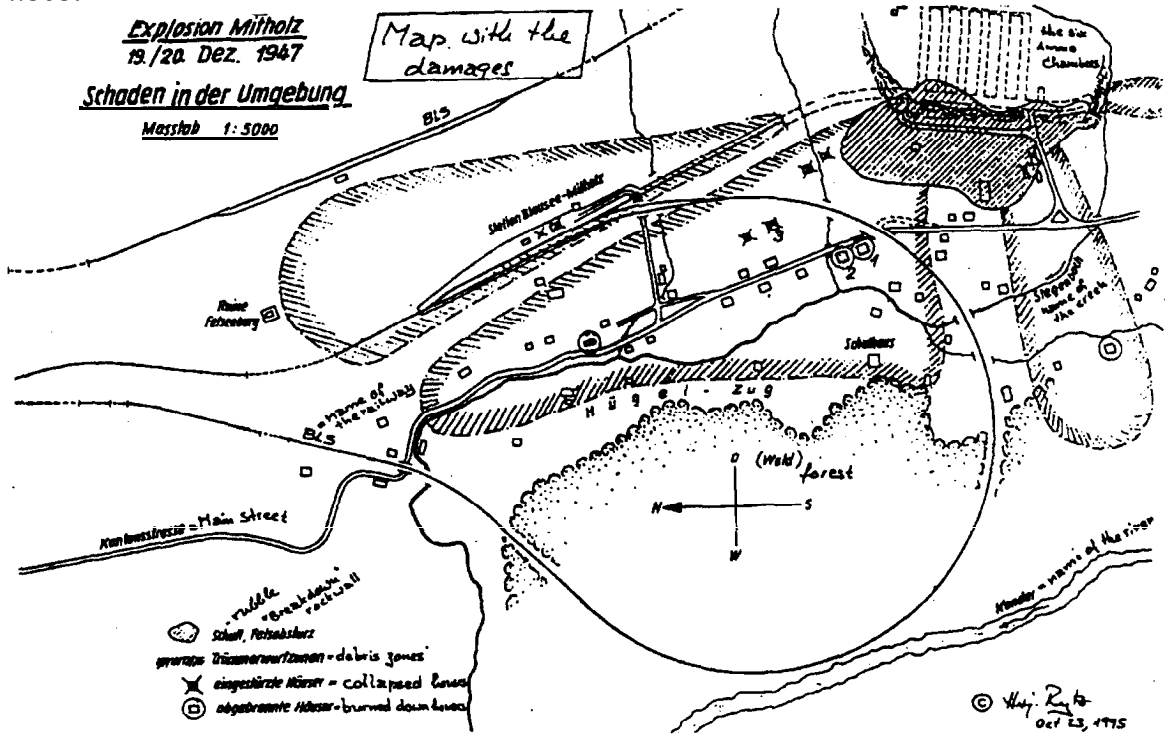


Figure 12. Topographic Map Used to Describe Various Damage Zones.

The Southwest Damage Zone was 450 m long causing the collapse of two office and one inhabited house buildings. A lot of thrown out pieces, items and debris were covered by falling parts of the rock wall.

The South Damage Zone was 100 m long and showed much less debris density and destruction.

Nine fatalities and lose of two live stock were reported.

During the 1948, the site clean up was conducted. It is estimated that about 40 % of the stored ammunition caused all the damage — roughly 3,000 tons detonated,

deflagrated or burnt, whereas 4,000 tons were thrown out, covered by rock falls or mechanically damaged.

The cause of the initial event was most probably a spontaneous initiation of copperacid in an Artillery fuse. Then probably a little sympathetic detonation occurred with subsequent burnings, deflagrations and detonations.

Between June 1946 and September 1948 there has been other accidents with similar but much less severe damages. However after the MITHOLZ accident the Swiss ammunition factories introduced safety modifications into the Artillery fuzes, and copper alloys such as no longer using brass as a material for elements in fuzes.

It has been summized that the initial reason for the accident was a copperacid detonation. This has been confirmed by the fact that this was the last accident in an ammunition storage magazines in Switzerland.

5. ANALYSIS BASED ON BAKHTAR CRITERIA

The systematic procedure outlined by the Bakhtar Explosives Safety Criteria (BESC) for performance assessment of responding/non-responding underground munitions storage magazines will be followed for the proposed study. Using this approach a more elaborate documentation of the Mitholz accident, and calculation of the total weight of explosives (TNT equivalent) which caused the accident, will be made. The first step in such analysis include collection of site specific data on the geologic and engineered systems as shown schematically in Figures 13 and 14. The collected data can then be used for the performance assessment of the magazine and subsequent calculations of the loading density as indicated in Figure 15.

6. REMARKS

The unfortunate incident at the Mitholz underground ammunition storage magazine has provided the Swiss explosives safety community an opportunity to compile "real" data from a full scale event. Such data are extremely valuable for validation of safety standards, such as the Bakhtar's Criteria, and optimization of design and loading density for the next generation underground munitions storage magazines.

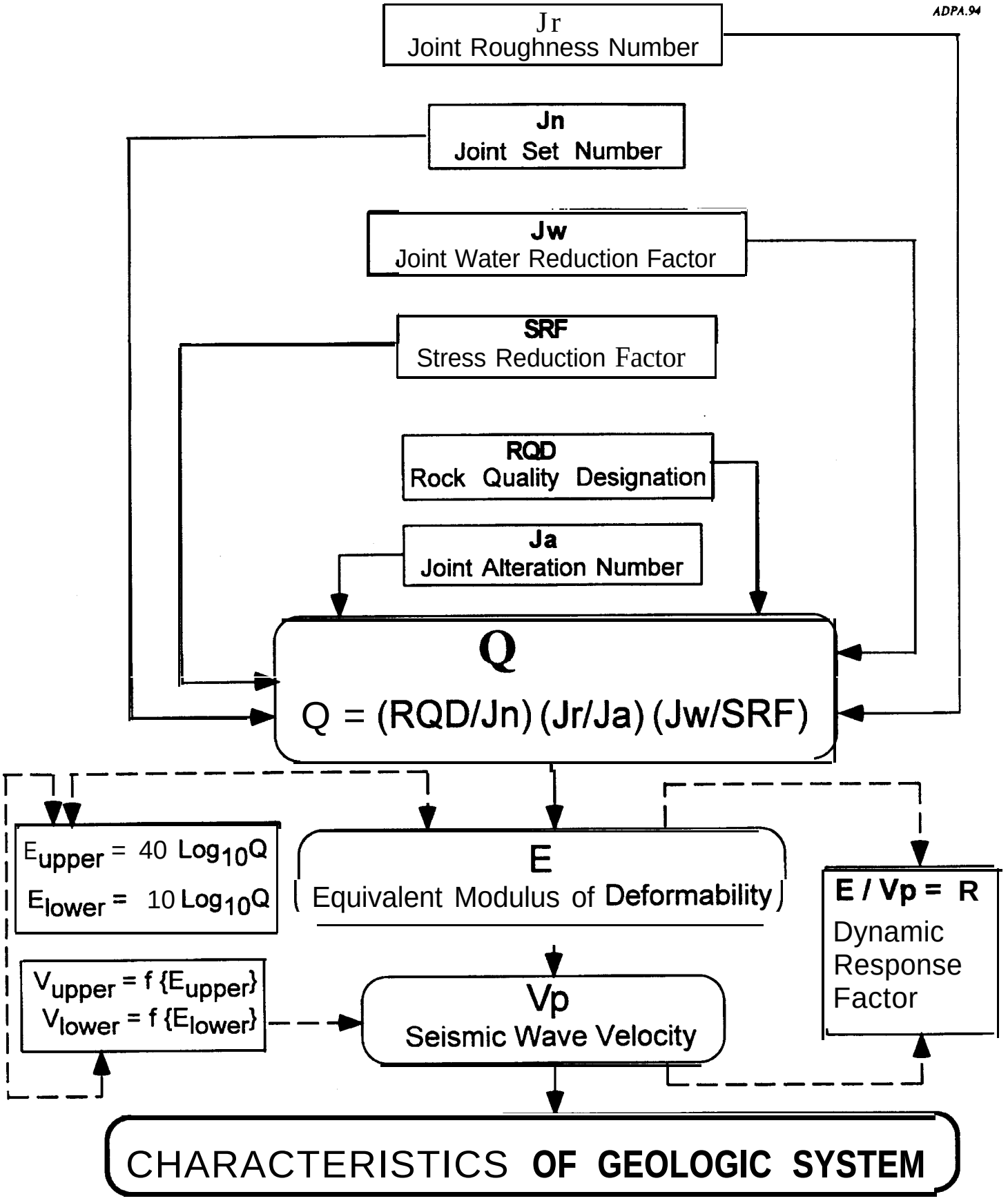


Figure 13. Characterization Procedure for Geologic System.

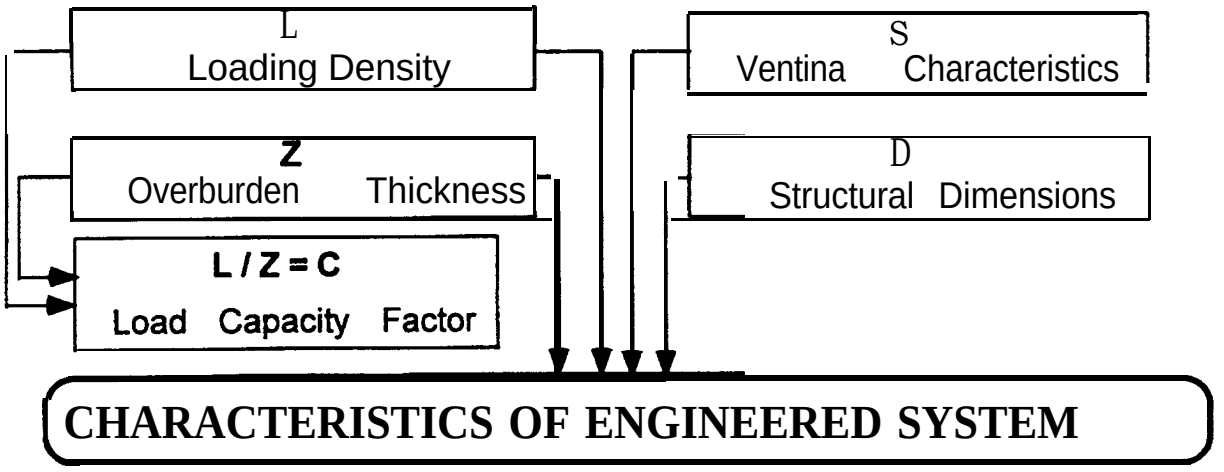


Figure 14. Characterization Procedure for Engineered Systems.

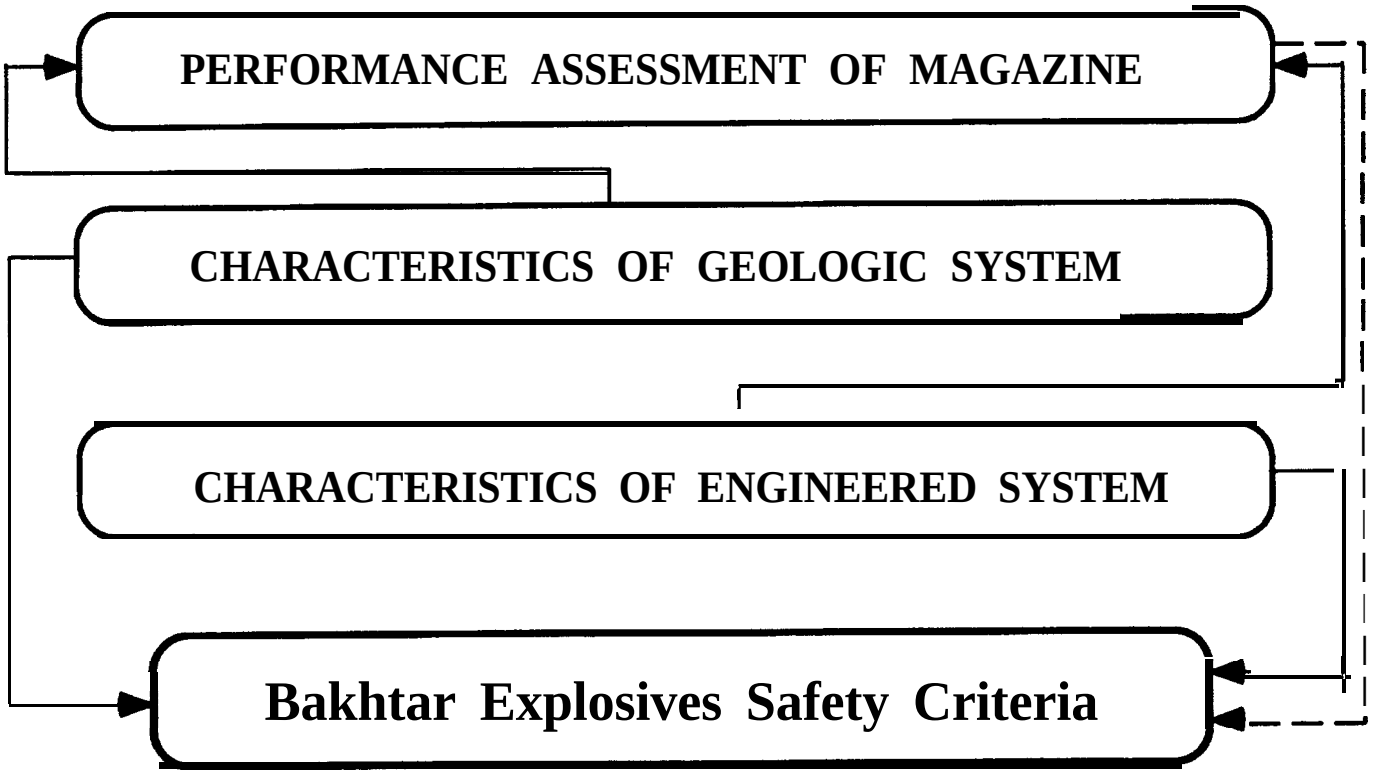
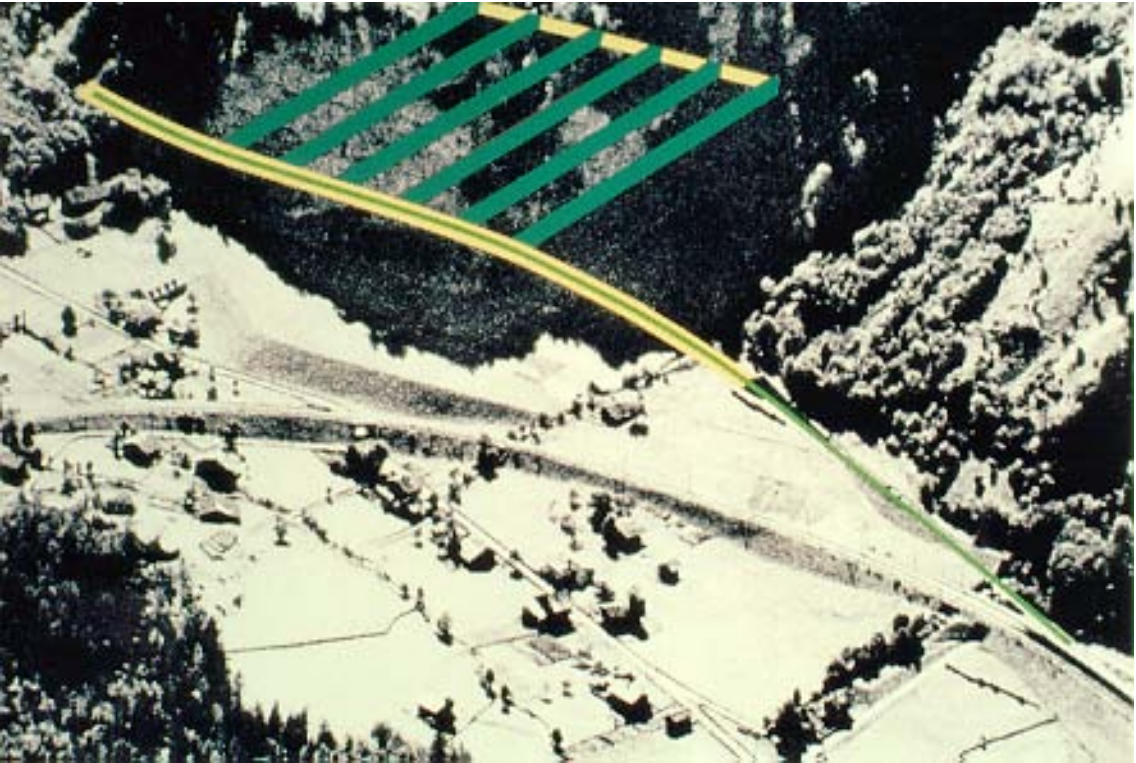
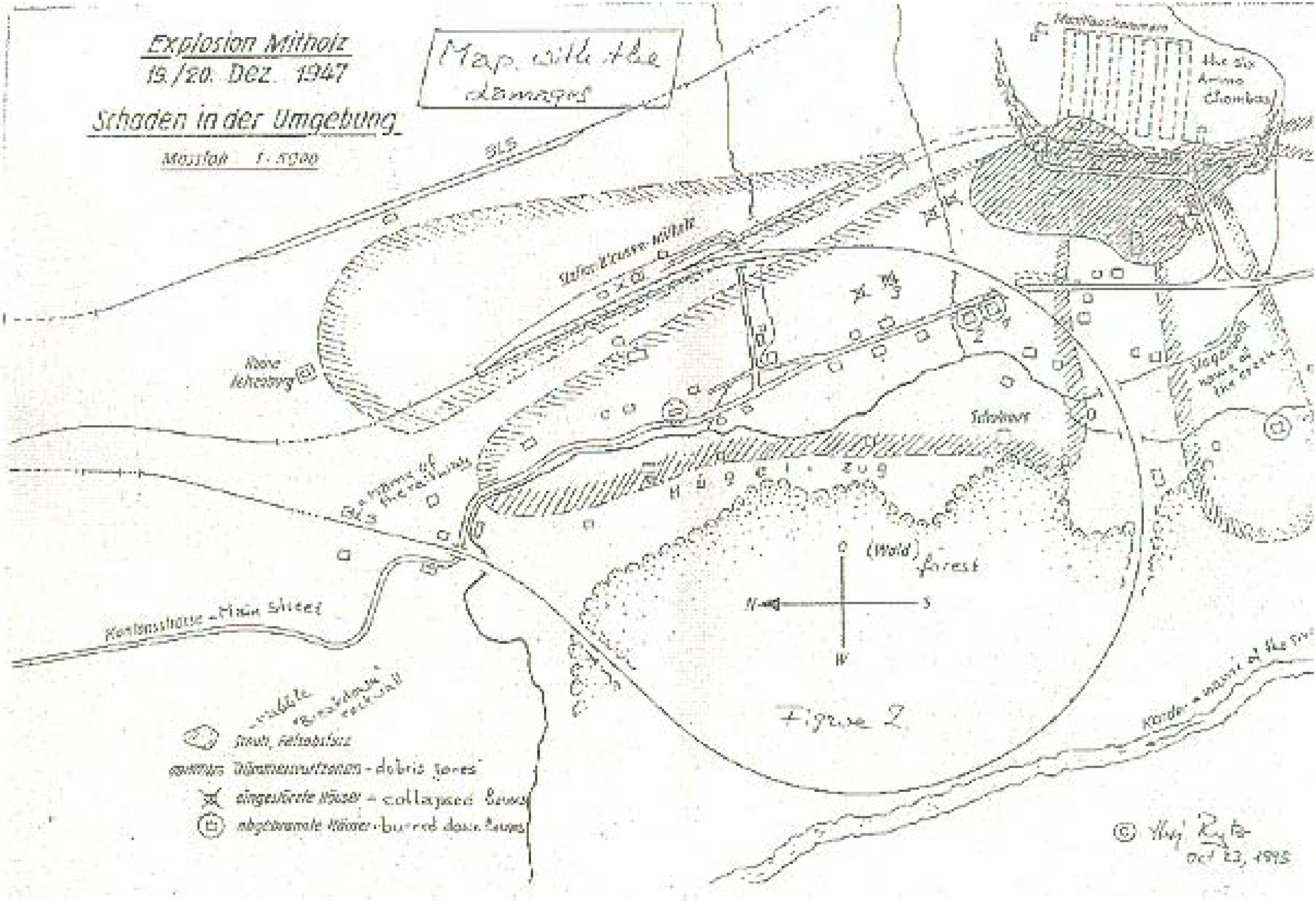


Figure 15. Response Evaluation Based on The Bakhtar Criteria.




Explosion Mitholz
19./20. Dez. 1947
Schaden in der Umgebung
Map with the damages
SLS
BLS
Hügelzug
(Wald) forest
N
S
O
W
Figure 2
dobris zones
collapsed houses
burned down houses
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